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ABSTRACT

The defining attributes of analytic ability as they relate to theoretical cognitive styles were explored in a study using a sample of 492 males aged 16-21 years. The Group Embedded Figures Test (GEFT--Witkin, Oltman, Rasher, and Karp) was used to measure field dependent and independent aptitude. Scores on the GEFT were compared with scores on an adaptation of Kagan's visual analysis task, i.e., the Test of Analytic Aptitude (Messick). This test requires each subject to learn nonsense syllable labels for a series of complex geometric designs, and then asks them to supply the appropriate design label for a single aspect of the previously learned design; this single aspect, or part, is termed a design variation. Results indicate that performance in a test of embeddedness and cognitive restructuring is highly related to performance on a Test of Analytic Attitude, and support the view that the degree of differentiation exhibited by field independent and field dependent learners will affect analytic strategies used to process visual information. The relationship between these measures can be interpreted to support a view of common underlying analytic and non-analytic tendencies. Thirty references and nine data tables are included. (LMM)

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TITLE: Defining Attributes of Analytic Ability as a Prerequisite for Selection of Instructional Strategies

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DEFINING ATTRIBUTES OF ANALYTIC ABILITY AS A PREREQUISITE FOR SELECTION OF INSTRUCTIONAL STRATEGIES

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INTRODUCTION

This study supports the view that the degree of differentiation exhibited by field-independent and field-dependent learners will affect analytic strategies used to process visual information. The purpose of this study was to explore the defining attributes of analytic ability as they relate to theoretical cognitive styles originally described by both Witkin, Dyk, Paterson, Goodenough and Karp, (1962) and Kagan, Moss & Sigel, (1963).

RATIONALE

Technical and vocational training relies heavily on the use of visuals. The instructional designer is faced with a recurrent question of how to design visuals which facilitate effective, efficient processing of information. Often technical line - drawings are required, which demand analytic skills in perceptual and cognitive restructuring (Cf. Witkin, Moore, Goodenough & Assoc., 1977).

When learners are to perform a concept attainment task, they are required to use a stylistic capacity to break down the line - drawing into its component parts (in an analytical manner) as a prerequisite for processing the concept information (Witkin, Moore, Goodenough & Cox, 1977). Field-independent learners have demonstrated more effective strategies in tasks which demand analytic skills in perceptual and cognitive restructuring, whereas the field-dependent learner:

> ...is likely to have difficulty with that class of problems, where the solution depends on taking some critical element out of the context in which it is presented and restructuring the problem material so that the item is now used in a different context. (Witkin and Goodenough, 1977, p.8).

Kagan, Moss and Sigel (1963) have also identified a strategy of information processing which they described in terms of a tendency to analyse stimuli into differentiated parts, as opposed to a non-differentiated, global acceptance of the entire stimulus.

The common use of the terms analytic and non-analytic by both Witkin (Witkin, Dyk, Faterson, Goodenough, and Karp, 1962) and Kagan (Kagan, Moss and Sigel, 1963) has tempted several researchers to suggest that the field-dependence-independence notion of Witkin, and the dimension studies by Kagan, may relate to the same ability (Doyle 1965, Messick and Fritzky 1963, Stanes and Gordon 1973, Wachtel 1968). Cronback and Snow (1977) have noted that the constructs of Kagan and Witkin appear to be conceptually related.

Accurate codification of the analytic term may be crucial in some aspects of cognitive style research. According to Wallach (1962), the essential task for those conducting research on cognitive style is to ascertain each style's defining attributes. Knowledge of these stylistic attributes will guide the investigator in a search for other "manifestations of the 'same' style" (Wallach, 1962, p. 199). Furthermore, increased knowledge of relevant stylistic attributes and learner processing capacities may aid in the specification of effective instructional design strategies for concept attainment tasks. Ausburn and Ausburn (1978) have pointed out that knowledge of stylistic attributes is necessary a prerequisite for selection of instructional design strategies which consider the processing demands of the learning task. The need for consideration of processing demands has been highlighted by research which has shown that individuals are likely to favor and do better in tasks in which they are suited by their cognitive style (Cronbach and Snow 1977, Witkin and Goodenough, 1977).

The rationale for this study is based on the following assumptions:

- the better a visual is perceived, the better it can be encoded, remember and utilized.
- a learner's ability to implement effective processing strategies is influenced by task demands, media attributes and learner aptitude.
- learning will be most effective when task demands and media attributes either precisely complement the processing aptitude of the learner, or adapt to the learner's aptitude.
- increased knowledge of the stylistic attributes of analytic ability may aid in the design of instructional visual for concept attainment tasks.

DISCUSSION

This study defined the cognitive style, field-dependence-independence as reflecting an analytic ability termed fluid intelligence (cf. Cattel, 1971; Cronbach and Snow, 1977; Snow and Peterson, 1980). According to Horn (1976), fluid intelligence is measured in tests of reasoning which employ figural and non-word symbols: that is non-verbal intelligence tests. In theory, field-dependence-independence may be considered to be one expression of a more general individual difference dimension, defined at one extreme by a global mode of processing and at the other extreme by a more differentiated, analytical manner of processing (Witkin, Dyk, Faterson, Goodenough and Karp, 1962, 1974). In people with a relatively analytic cognitive style, experiences can be analysed, and if necessary, restructured through the use of internal referents. By contrast, in people with a relatively global cognitive style, experiences are governed by external referents and dominant organization of the field (Witkin and Goodenough, 1977). A central hypothesis in field-dependence-independence theory is that individual differences in expressions of articulated or differentiated functioning in one area are related to expressions in other areas. A considerable body of evidence supports this hypothesis (Witkin, Goodenough and Oltman, 1977). Thus, the more differentiated mode of the field-independent person is evidenced in a more active approach towards analysis and structuring in both perceptual and intellectual activities. Global cognitive functioning, on the other hand, is represented by a more passive manner of dealing with the field, accepting it as presented with limited analytical and structuring abilities in both perceptual and intellectual activities (Witkin and Goodenough, 1977).

In the typical concept-attainment problem, stimuli composed of a number of attributes are used. It has been suggested that problems of this sort may require perceptual and intellectual analysis of the stimulus complex into its relevant attribute components, a requirement that is more easily attained by field-independent learners (Dickstein, 1968). In this view, field-dependent subjects are dominated by the salient (that is, most noticeable) attributes of the stimulus, which may achieve a figural quality against the ground provided by other aspects of the stimulus configurations. When directed to construct hypotheses about the concept definition, these learners respond to the salient, external referents rather than sampling broadly from the set of available stimulus attributes, as field-independent individuals are likely to do (Kirschenbaum, 1968; Shapson, 1973).

This emphasis on strategies used by learners supports Cronbach and Snow's contention (1977) that the study of cognitive style should involve individual differences in process rather than content variables; that is, investigators should be more interested in individual differences in modes of processing information. Research has shown that individuals are likely to favor and do better in tasks in which they are suited by their cognitive style (Witkin and Goodenough, 1977). Field-independent people have demonstrated more effective strategies in concept learning tasks which demand analytic skills in perceptual and cognitive restructuring (Witkin & Goodenough, 1977).

Kagan, Moss and Sigel (1963) have also identified a strategy of information processing which they describe in terms of a tendency to analyse stimuli into differentiated parts, as opposed to a nondifferentiated, global acceptance of the entire stimulus. Kagan et al. noted the similarity of this dimension to the field-dependence-independence dimension studied by Witkin, Dyk, Faterson, Goodenough and Karp (1962). In reply, Witkin (1963) cautioned that despite many apparent similarities, there was still considerable question as to how closely the two concepts were related.

Attempts to investigate empirically the relation between the dimensions studied by Kagan and by Witkin were made by Messick and Fritzky (1963) and Wachtel (1968). Wachtel felt that if a relationship did exist between field-dependence-independence (Witkin's concept) and analytic attitude (Kagan's concept), it may be highlighted if extreme groups were studied and compared. Consequently, subjects for his study were preselected on the basis of their Embedded Figures Test performance, and then these extreme groups of field-dependents and field-independents were compared on a a measure of analytic attitude. He utilized a visual analytic attitude task developed for use with adults by Messick & Fritzky (1963). The task was modelled on one used by Kagan in his research with children. This test of analytic attitude was based on the following percept:

> An analytic child presumably differentiates complex arrays to a greater degree than a non-analytic child. That is, he applies labels to the whole stimulus as well as to the parts. He reacts to a different immediate environment, if the environment is defined, in part, as that sector of the stimulus field that is labelled. One method of testing this hypothesis is to require the individual to learn a response to a complex stimulus and to assess subsequently the degree to which the response is transferred to discrete parts of the original stimulus. (Kagan, Moss and Sigel, 1963, p.94)

Kagan's aim in developing this test was to assess its relationship to the conceptual styles or strategies used by individuals in concept formation tasks. He illustrated that children who scored as being "analytic" on the visual, analytic attitude test also tended to use a more active, analytical strategy in forming conceptual grouping, whereas children who scored towards the "global" end of the dimension on the analytic attitude test tended to use a more passive conceptual strategy, based on a global acceptance of the entire stimulus. Wachtel (1968) also related the visual Test of Analytic Attitude to a conceptual style task. However, a more significant outcome of his study was to point out a very strong relationship between Embedded Figures Test performance and scores on the Test of Analytic Attitude. Results should not be interpreted to mean that the two approaches measured exactly the same dimension.

Both Kagan et al. (1963) and Witkin (1963) stressed the multidimensional nature of their view of strategies used by individuals. Messick and Fritzky (1963) reflected that conceptually Kagan's test measured a tendency to experience items as discrete components of a visual field. Witkin, Kyk, Faterson, Goodenough and Karp (1962) have described field-dependence-independence not only as a tendency to experience items as discrete from their backgrounds, but also as ability to overcome the influence of an embedding context. The importance of the relationship of the two approaches appears to lie in their unique interaction in tasks that require analytic skills, since the overcoming of embedding influences would seem to be facilitated by a tendency to experience items as separate from their contexts and vice versa (Messick and Fritzky, 1963).

Accurate codification of the analytic term may be crucial in some aspects of cognitive style research. According to Wallach (1962), the essential task for those conducting research on cognitive style is to ascertain each style's defining attributes. Knowledge of these stylistic attributes will guide the investigator in a search for other "manifestations of this 'same' style" (Wallach, 1962, p. 199).

Research on Witkin's articulated-global dimension has raised the possibility that "analytic" or "articulated" functioning in his terms may consist of two separate but related factors: (a) reliance on internal (bodily) or external (visual) referents, as well as (b) greater or lesser competence in cognitive restructuring (Witkin and Goodenough, 1977). Furthermore, Witkin, Goodenough and Oltman (1977) have defined field-dependence-independence as "extent of autonomous functioning," (p. 24) with field-independent people demonstrating more autonomous, differentiated functioning through the use of internal

referents, and field-dependent individuals tending to prefer the use of external, visual referents in their global, less differentiated and less autonomous approach. Traditionally, field-dependence-independence has been associated with tests of embeddedness, for example, Group Embedded Figures Test (Witkin, Oltman, Raskin and Karp, 1971). In Witkin's recent differentiation model, embeddedness tests were specified as examples of cognitive restructuring tasks (Witkin, Goodenough and Oltman, 1977). In summary, Witkin's current view of the analytic-global dimension is defined by two factors relating to disembedding and to autonomy which are evidenced in that reflect a state behaviors of relatively greater or less differentiation (Witkin, Goodenough and Oltman, 1977). By implication, performance on tasks which require analytic structuring, for example, concept acquisition tasks and Kagan's visual analysis task (that is, Test of Analytic Attitude), may also reflect the individual's state of differentiation. As field-independent cognitive style has been associated with more differentiated functioning, high performance on analytic structuring tasks may be related to ability to structure experience into discrete parts, as well as capacity to disembed relevant details and restructure information as required. As field-dependent cognitive style has been associated with less differentiated functioning, low performance performance on analytic structuring tasks may be related to lack of ability to structure experience into discrete parts as well as less capacity to dissembled relevant details and restructure information as required.

METHOD:

For convenience in data collection, it was decided to use the Group Embedded Figures Test (Witkin, Oltman, Raskin and Karp, 1971), as a measure of field-dependent-independent aptitude. Only students designated as extremely field-dependent or extremely field-independent by their Group Embedded Figures Test (GEFT) score were included in the study. Scores were analysed with the upper and lower 26% of scores determined to represent the extremes of field-independent and field-dependent subjects respectively. This technique followed statistical procedures of Kelly (1939), Greco and McClung (1979) and McClung (1975). Cronbach and Snow (1977) have recommended the use of high and low extreme groups by pointing out that such a design is appreciably more powerful than a study with the same sample population distributed over the full aptitude range.

This study sought to compare scores on the GEFT with scores on an adaptation of Kagan's visual analysis task, that is, the Test of Analytic Attitude (Messick, 1962). Messick and Fritzky (1963) and Wachtel (1968) have utilized this adaptation for adults of the visual analysis task developed by Kagan, Moss and Sigel (1963). The adult version of the task first requires each subject to learn nonsense syllable labels for a series of complex, geometric designs. Next, the subjects are asked to supply the appropriate design label for a single aspect (part) of the preveiously-learned

design. For example, the subject might be shown only the background pattern from the original design or just isolated elements from the original design. In other words, the Test of Analytic Attitude measures each subject's capacity to identify part aspects, termed design variations, from previously-learned designs.

Dependent variables consisted of seven different scores on the analytic attitude task. The first, termed ORIG, refers to the measure of the subjects' ability to memorize the six original, complete designs together with their nonsense syllable labels. The ORIG score refers to the number of original designs correctly identified before presentation of the design variations. The remaining six dependent variables refer to the six types of variations of the original designs that were utilized in the test of analytic attitude. An example of an original design and its six variations are illustrated in Figure 1.

These variations are of the following types:

Variation 1 — The original figure composed of the original elements, with no background (denoted ef-, for element, figural form, no background).

Variation 2 — Original background only (--b).

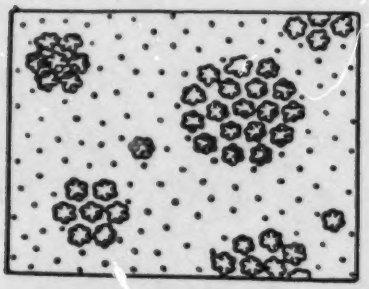
Variation 3 — The original element uniformly spaced against the original background, with no figural form (e-b).

Variation 4 — The original element uniformly spaced with no background and no figural form (e--).

Variation 5 — The original figural form represented by means of a new and different element, with no background (-f-).

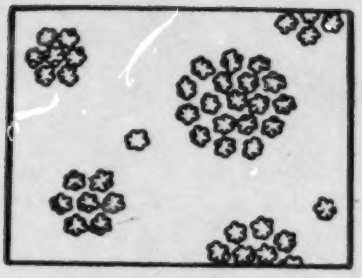
Variation 6 — The original figure indicated by enclosing lines against the original background, with no element (-fb-).

This test of analytic attitude was composed of two sections. The first section was called "Memory for Designs" (Orig.) by Messick and Fritzky (1963). In the present study, this section was termed "ORIG'. This first test section required each subject to learn six, original designs so that they could be recognized by name. Each subject was given a page containing six complex, geometric designs, under each of which was printed a nonsense-syllable label. Each original design consisted of a figural form, made up of discrete elements, and a background pattern. After the defined time limit, this page was replaced by a second page which presented the six designs again, but in a different order and without their labels. Subjects were asked to supply the appropriate nonsense syllable label for each design.

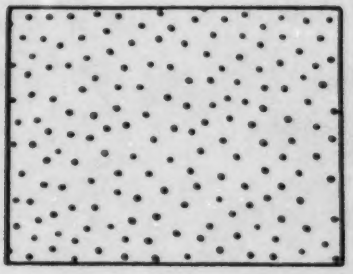


VIS

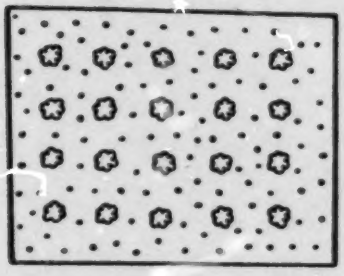
The Original Design



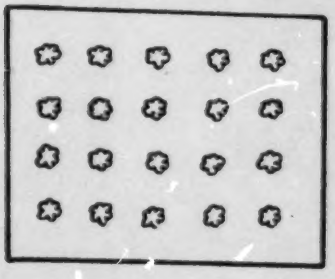
Var.1 ef-



Var.2 --b

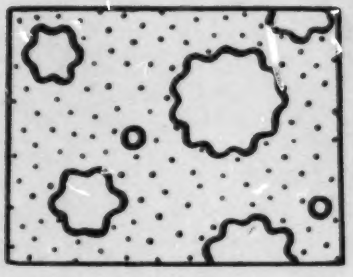


Var.3 e-b



Var.4 e--

Var.5 -f-



Var.6 -fb

Figure 1 : Examples of an original design "vis" and its six variations. (Adapted from a Measure of Analytic Attitude devised by S. Messick, 1962.)

After a short period, this test page was replaced by a second section of the task. Messick and Fritzky called this second section "Identifying Variations". The second section consisted of a booklet containing thirty-six designs; that is, six variations of each of the original six complex designs. These variations consisted of either the background pattern, the original figural form or shape without the elements, the original elements alone, or some combination thereof. The subjects were required to supply the appropriate label for each variation based on their learning of the six original complex designs. It should be noted that the six nonsense labels were boldly printed across the bottom of all pages in both Section I and II of this task. Thus, subjects were not require to hold the actual, verbal labels in memory. A sample page from the test booklet's shown in Figure 2.

In summary, this study sought to determine whether a relationship existed between the scores for the six design variations and extreme scores on the field-dependence-independence dimension as measured by the Group Embedded Figures Test (Witkin, Oltman, Raskin and Karp, 1971). Three types of scores were compared with field-dependence-independence scores:

1. the six "variations" scores

2. a total score for the six variation scores combined

3. a memory score (ORIG) for the original six designs and their nonsense syllable labels.

Of a sample of 492 males aged from 16-21 years, 113 were determined to score within the extreme field-dependent range, and 106 were designated as having extreme field-independent cognitive style.

An Overview of Data Analysis

A one-way analysis of covariance was used to analyse data. The score for the number of correctly identified original designs; that is, the original memory score (ORIG), was utilized as the covariate. The ORIG variable was inserted into the design to control and remove extraneous variation from the remaining seven dependent variables; that is, the six individual variations scores plus the composite score. Field-dependent-independent aptitude was the categorical independent variable of primary interest to the analysis. To determine the effect of this factor on test scores, regression procedures were used to remove variation in each dependent variable due to the covariate (ORIG). Conventional analysis of variance then was performed on the "corrected" scores. Where analysis revealed significant differences, visual inspection of the two relevant aptitude means indicated the nature of the difference.

Figure 2: Sample Test Page

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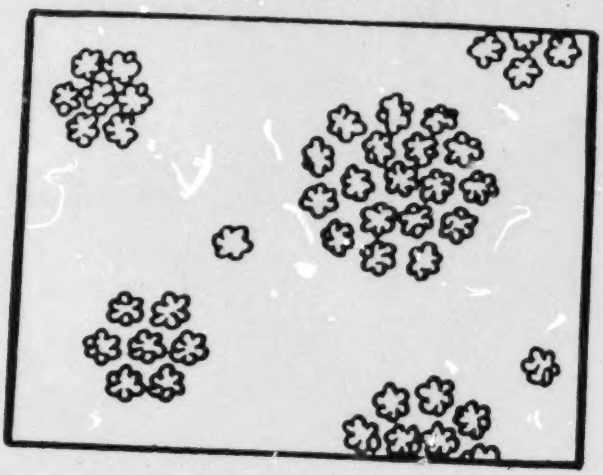

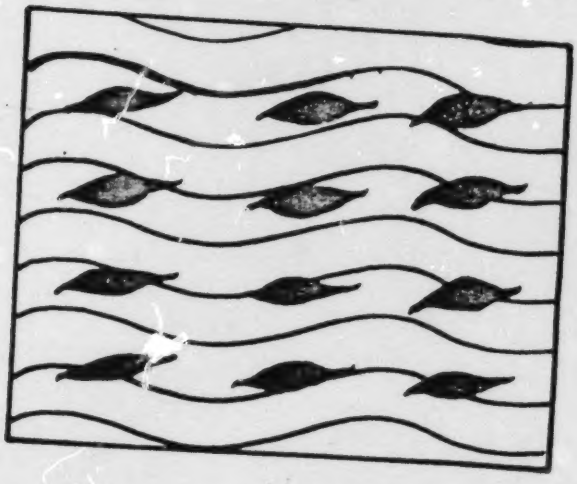

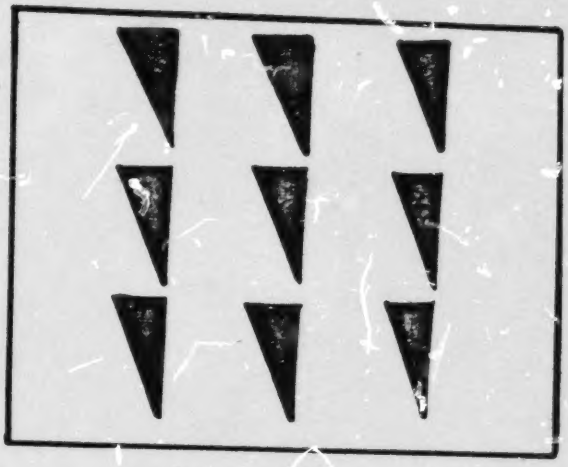

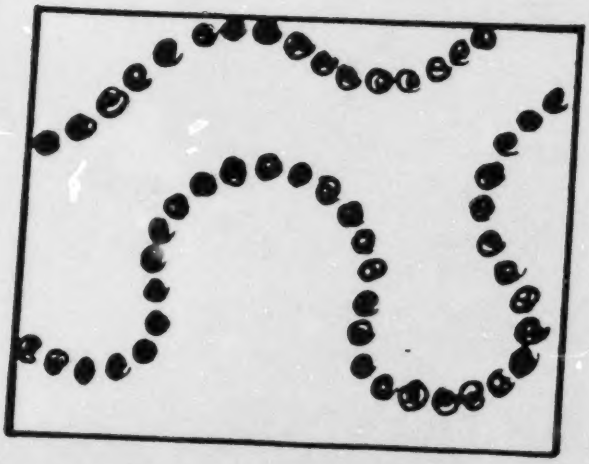

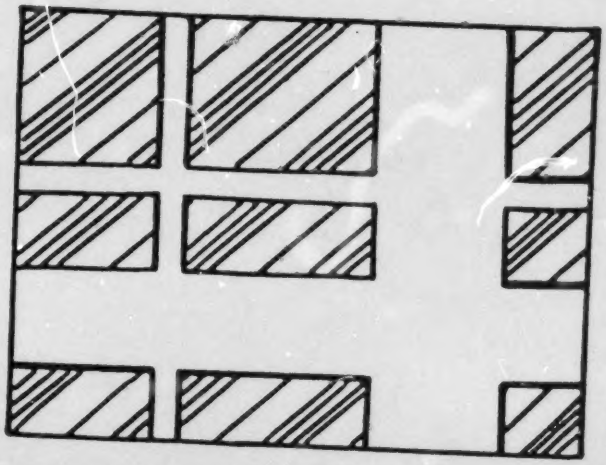

KAV VIS SEP LIF WOM PUE

Supplementary analyses were conducted to aid in the interpretation of results. These analyses included:

1. Measures of the sensitivity of the design. Determinations of appropriate sample size and power were conducted using procedures given by Cohen (1969) and Keppel (1973).

2. Estimates of treatment magnitude (Omega squared). These estimates were constructed using procedures given by Keppel (1973, 1982) and Kirk (1968).

3. Tests for homogeneity of variance for all measures. These tests were conducted using procedures given by Kirk (1968) and Winer (1971).

4. Estimates of reliability (r_{tt}). The Kuder-Richardson (K-R) formula 21 was used to estimate the reliability of measures used. Formula and procedures were given by Guilford, (1973, pp. 417-418). It should be noted that this Kuder-Richardson formula tends to underestimate the reliability of a test (Guilford, 1973).

RESULTS AND INTERPRETATION OF FINDINGS

Analysis of the Original Memory Score (ORIG)

The original memory test was conducted to ensure that both the field-dependent aptitude group and the field-independent aptitude group were equivalent in their ability to memorize the six, original, complete designs together with their nonsense syllable labels. Comparison of the two group means revealed that there was a significant difference between the ORIG scores of the two aptitude groups, t (149) = 3.82, $p<.001$. It is important to note the the t value was based on a separate variance estimate because of the violation of the homogeneity assumption.

Because of the statistically different difference between field-dependent subjects and field-independent subjects on the ORIG test, it was determined that subsequent analyses of all test measures would utilize analysis of covariance with the ORIG scores held constant as the covariate.

Analysis of the Composite Score

HO_1: There is no difference in performance of field-dependent or field-independent subjects on a test of analytic attitude.

The null hypothesis was rejected for the total performance measure (the composite score). That is, field-independent subjects' total performance was significantly greater than field-dependent subjects' total scores on a test of analytic attitude. Estimates of treatment magnitude (omega squared) revealed that the main effect for aptitude accounted for 18% of the total variance. According to interpretative conventions proposed by Keppel (1982) and Cohen (1977), this estimate may be considered to represent a large effect. Table 1 shows a summary for the analysis of covariance for the composite score.

Analysis of Variations Scores 1-6

HO_2: There is no significant difference in performance of field-dependent or field-independent subjects for any of the design variations on a test of analytic attitude.

The null hypothesis was rejected for each of the six variation scores. That is, field-independent subjects' scores were significantly higher than field-dependent subjects' scores on each of the design variations in a test of analytic attitude (see Tables 2-7). Estimates of treatment magnitude (omega squared) revealed that the main effects for aptitude accounted for: (a) 6.2% of total variance on the variation 1 score; (b) 16.2% of total variance of the variation 2 score. (c) 9% of total variance on the variation 3 score; (d) 7% of total variance on the variation 4 score; (e) 20% of total variance on the variation 5 score; (f) 19% of the total variance on the variation 6 score. These tests of treatment magnitude for variation 2, 5 and 6, suggest that aptitude differences accounted for large proportions of the total variance for each of these three measures.

Post hoc analyses of power revealed that the size of the effects for aptitude plus the large sample sizes and small error term combined to result in extremely high power estimates (>.95) for all of the variations scores and the composite score. These results increased the confidence in: (a) the sensitivity of the experiment to detect real differences, and (b) the correctness of all decisions to reject null hypotheses.

The reliability coefficients for variations r_{tt} = .61 (variation 1), r_{tt} .70 (variation 2), r_{tt} = .67 (variation 3), r_{tt} .64 (variation 4), r_{tt} = .64 (variation 5), r_{tt} .65 (variation 6), and r_{tt} = .92 (composite score).

Cronbach and Snow (1977) have recommended the inclusion of descriptive statistics in the analysis of data relating to subject aptitude. Consequently, aptitude group means and standard deviations have been presented in Table 8.

Results of Hartley's Test of Homogeneity of Variance for all posttest scores are reported in Table 9.

Discussion and Interpretation of Results

In summary, performance on a test of embeddedness and cognitive restructuring (GEFT) was found to be highly related to performance on a Test of Analytic Attitude. The relationship between these measures can be interpreted to support a view of common, underlying analytic/non-analytic tendencies (cf. Messick and Fritzky, 1963; Wachtel, 1968). Findings should not be interpreted to mean that non-analytic/analytic attitude and field-dependent/field-independent cognitive style are identical constructs. The redefinition of field-dependence-independence within differentiation theory has extended this dimension from a narrow perceptional view to a broader multidimensional view of individual functioning.

Results confirm Wachtel's finding (1968) of a general superiority for field-independent subjects in identifying element, figural form and background aspects. Both the results from the present study and the results from Wachtel, are somewhat inconsistent with those of Messick and Fritzky (1963), who found that the field-dependence-independence dimension related only to the element variations of the original designs. Wachtel (1968) found almost all variation types to be significant. He noted that he had used a powerful experimental design. Messick and Fritzky did not use extreme groups. Instead, they utilized an unselected ample of subjects representing a wide range of Embedded Figures Test (EFT) scores. The present study supports Wachtel's assertion that a positive relationship between all scores for design variations on a test of analytic ability and EFT performance will be revealed, if the more powerful extreme groups design is used.

Study of differentiation theory has extended this dimension from a narrow perceptional view to a broader multidimensional view of individual functioning. It is suggested that the observed relationship between performance on the Group Embedded Figures Test and a Test of Analytic Attitude illustrates differentiated/analytic tendencies which can be related to aptitude processes strategies and resultant performance in a concept attainment task. The following interpretation of findings is offered:

The attainment of concepts from line-drawings is favored by more analytic, differentiated modes of processing. The successful application of this mode allows more differentiated field-independent individuals to avoid domination by the overall organization of the stimulus field, the embedding

context. As a consequence these learners are more able to isolate analytically, the relevant concept attributes. This serves as a necessary prerequisite for competent execution of processes through which the concept attributes are defined, combined and associated to form each concept. For field-independent learners, these processes have been associated with wholist, hypothesis-testing strategies. The isolation of all relevant details is imperative in order to form a comprehensive first hypothesis which will subsequently be tested, modified and revised through this hypothesis-testing strategy. Extremely field-dependent individuals are less capable of differentiated functioning. They appear to experience difficulty in overcoming the embedding context and thus lack the restructuring ability necessary to isolate relevant details. Their difficulty is particularly apparent when processing time is limited by externally-paced presentations.

Thus, the difficulty evidenced in isolating details (part aspects) of the visual may inhibit competent execution of processes through which the concept attributes may be defined, combined and associated to form each concept. These results provide the following instructional design challenge:

> Given an aptitude variable and some analyses of the processes it reflects, one then asks: What instructional techniques would make this competence especially relevant to learning? What would a treatment have to provide to make learning easy for the low-aptitude S? (Cronbach and Snow, 1977, p. 172)

Investigations to answer this challenge are needed to provide real-world significance for the practitioner who uses line-drawings to teach concepts and wishes to consider cognitive style attributes. Such a blend of research, theory and practice is imperative for the design of aptitude sensitive instruction.

Table 1

Analysis of Covariance for Scores on the Composite Measure (Study II)

Source of Variance	SS	df	MS	F
(ORIG) - Covariate	2697.265	1	2697.265	55.121
Aptitude	2974.712	1	2974.712	66.791*
Explained	5671.976	2	2835.988	57.956
Residual	10569.567	216	48.933	-
TOTAL	16241.543	218	74.502	-

* $p < .0001$

Table 2

Analysis of Covariance for Scores on Variation I
(Study II)

Source of Variance	SS	df	MS	F
(ORIG) - Covariate	85.336	1	85.336	52.151
Aptitude	30.995	1	30.995	18.942*
Explained	116.331	2	58.166	35.546
Residual	353.449	216	1.636	-
TOTAL	469.781	218	2.155	-

* $p < .001$

Table 3

Analysis of Covariance for Scores on Variation 2
(Study II)

Source of Variance	SS	df	MS	F
(Orig) - Covariate	90.346	1	90.346	35.592
Aptitude	126.873	1	126.873	49.982*
Explained	217.219	2	108.610	42.787
Residual	548.288	216	2.538	-
TOTAL	765.507	218	3.511	-

* $p < .0001$

Table 4

Analysis of Covariance for Scores on Variation 3
(Study II)

Source of Variance	SS	df	MS	F
(ORIG) - Covariate	89.107	1	89.107	45.852
Aptitude	53.860	1	53.860	27.714*
Explained	142.967	2	71.484	32.783
Residual	419.772	216	1.943	-
TOTAL	562.740	218	2.581	-

* $p < .001$

Table 5

Analysis of Covariance for Scores on Variation 4
(Study II)

Source of Variance	SS	df	MS	F
(ORIG) - Covariate	105.481	1	105.481	55.182
Aptitude	43.961	1	43.961	22.998*
Explained	149.442	2	74.721	39.090
Residual	412.887	216	1.912	-
TOTAL	562.329	218	2.579	-

* $p < .001$

Table 6

Analysis of Covariance for Scores on Variation 5
(Study II)

Source of Variance	SS	df	MS	F
(ORIG) - Covariate	33.190	1	33.190	13.545
Aptitude	140.034	1	140.034	57.146**
Explained	173.224	2	86.612	35.346
Residual	529.296	216	2.450	-
TOTAL	702.521	218	3.223	-

* $p < .0001$

Table 7

Analysis of Covariance for Scores on Variation 6
(Study II)

Source of Variance	SS	df	MS	F
(ORIG) - Covariate	67.072	1	67.072	30.258
Aptitude	129.381	1	129.381	58.367*
Explained	196.453	2	98.227	44.312
Residual	478.807	216	2.217	-
TOTAL	675.260	218	3.098	-

* $p < .0001$

TABLE 8

Group Means and Standard Deviations for Field-Dependent and Field-Independent Aptitude

	Test Measure	APTITUDE						ROW	
		Field-Dependent						Field-Independent	
		$\bar{x}$	(SD)	n	$\bar{x}$	(SD)	n	$\bar{x}$	n
a	Original Score	5.72	(0.62)	113	5.95	(0.21)	106	5.83	219
1.	Variation 1	4.12	(1.61)	113	5.15	(1.10)	106	4.62	219
2.	Variation 2	2.56	(1.68)	113	4.35	(1.60)	106	3.42	219
3.	Variation 3	3.88	(1.73)	113	5.15	(1.20)	106	4.49	219
4.	Variation 4	3.74	(1.71)	113	4.95	(1.23)	106	4.33	219
5.	Variation 5	2.24	(1.56)	113	3.98	(1.62)	106	3.08	219
6.	Variation 6	3.83	(1.62)	113	4.59	(1.41)	106	3.68	219
Composite Score		19.33	(8.04)	113	28.20	(6.79)	106	23.62	219

TABLE 9

Results of Hartley's Test of Homogeneity of Variance for all Posttest Scores

Test Measure	Largest Variance	Smallest Variance	df	F_{max}
a. Original (ORIG) Score	0.3823	0.0454	2,112	8.45*
1. Variation 1	2.5986	1.2012	2,112	2.16*
2. Variation 2	2.8325	2.5504	2,112	1.11*
3. Variation 3	2.9929	1.4400	2,112	2.08*
4. Variation 4	2.9207	1.5228	2,112	1.92*
5. Variation 5	2.6374	2.4196	2,112	1.09*
6. Variation 6	2.6244	1.9994	2,112	1.31*
Composite Score	64.6416	46.1041	2,112	1.40*

* $p < .05$

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